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NASA National Aeronautics and Space Administration

Report To Educators

Vol. 8. No. 1 Spring 1980

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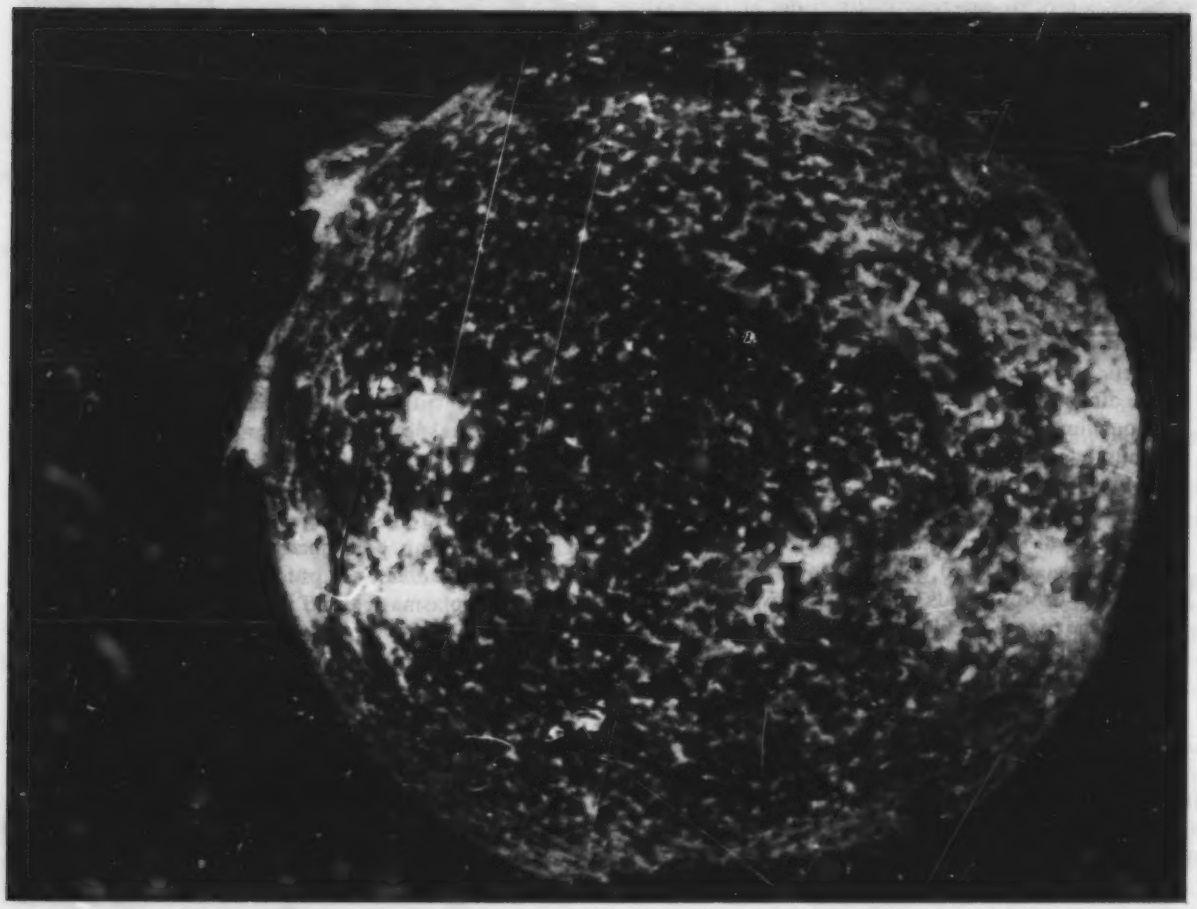
Solar Maximum Mission

On February 14, 1980, atop a Delta rocket, NASA launched the first spacecraft designed specifically for the study of solar flares. Operating in a circular orbit 579 km (360 mi) above the equator, the Solar Maximum Mission (SMM) observatory represents a major step toward a better understanding of the violent nature of the Sun and its effects on Earth.

The mission was planned to coincide with the solar maximum period, the peak of an 11-year sunspot cycle when particularly explosive activity disrupts the Sun's surface. The satellite, carrying seven instruments, will provide scientists with observations of solar flares—violent eruptions on the Sun's surface—over a wide band of wavelengths in the ultraviolet, x-ray, and gamma ray regions of the spectrum. Through coordinated observations at many different wavelengths, scientists expect to



Solar flare photographed by Skylab 4 on December 19, 1974.

NAS 1.49:

obtain many clues about the complex nature of solar flares and how they might be predicted.

The Sun. A middle-aged, middle-sized star in our galaxy of some 200 billion stars, the Sun has a remaining lifetime of about five billion years. Some stars are hundreds of times larger than the Sun; most are much smaller.

The visible surface of the Sun, the photosphere, transmits most of the Sun's light and heat. It is not a true surface, but represents the lowest gas layer from which visible light can be radiated into space. Other parts of the Sun include the middle atmosphere, or chromosphere, which extends a few thousand miles above its surface, and the outer atmosphere, or corona—a very thin, very hot gas, up to two million degrees C (3.5 million F)—that extends several solar radii into space and is the source of the solar wind.

Although the Sun appears stable when viewed from Earth, its surface has variations such as sunspots, solar prominences, and solar flares.

The first solar variation to be recognized was seen by Galileo in 1610 when he observed and described spots on the Sun's surface. During the next two centuries there was a succession of discoveries: that sunspot activity varies over an 11-year cycle; there is a "sunspot maximum" of two or three years; that Earth's magnetic field intensity rises and falls in an 11-year cycle, matching the sunspot cycles; and there are strong magnetic fields inside the sunspots.

Twentieth century scientists began daily observations of solar energy output, important measurements because fluctuation in the Sun's brightness of as little as 0.2% can affect Earth's climate.

Scientists believe that the magnetic field extending out through the surface of the Sun somehow gathers itself into an enormously compressed bundle to form a magnetic knot. This becomes visible as a sunspot, a region whose dimensions often are greater than the entire Earth, and sometimes, as a looping cloud of dense gas, hundreds of thousands of miles long, known as a solar prominence.

In 1958, the "solar wind," an outflow of electrically-charged subatomic particles from the Sun, was theoretically predicted. The particles are deflected and trapped by the Earth's magnetic field, collecting in a vast doughnut of space tens of thousands of miles above the Earth's surface. The energy of collision of these particles with the atoms of the upper atmosphere near Earth's magnetic poles produces light—the auroras.

Since the incidence of auroral activity rises and falls with the sunspot cycle, scientists believe that the solar wind does also. Thus, the more sunspots the greater the variations of the solar wind.

Solar Flares. Also in 1958, a sudden point of brightness on the Sun's surface that lasted five minutes, and then subsided was observed. The first recorded "solar flare" had been seen.

A solar flare is an explosion on the Sun's surface which sends a vast burst of material outward. The section of the solar wind immediately outward from the solar flare is much denser and more intense than it would ordinarily be, creating a "solar gust." A large solar gust can reach Earth in a matter of a few days, and the effects are seen and heard: there are severe disruptions in radio and television communications, surges in power transmission lines, auroral displays, and possible reductions in the lifetimes of some orbiting spacecraft. Some meteorologists suspect that increased solar activity also influences Earth's weather and climate.

Solar flares occur in the Sun's upper chromosphere and lower corona, close to but not exactly over the sunspots. It is not known precisely how or why the enormous energy release takes place, but part of the scientific fascination with flares stems from their enormous power. A major surface flare will release in a few minutes more energy than man can produce in a million years at present rates.

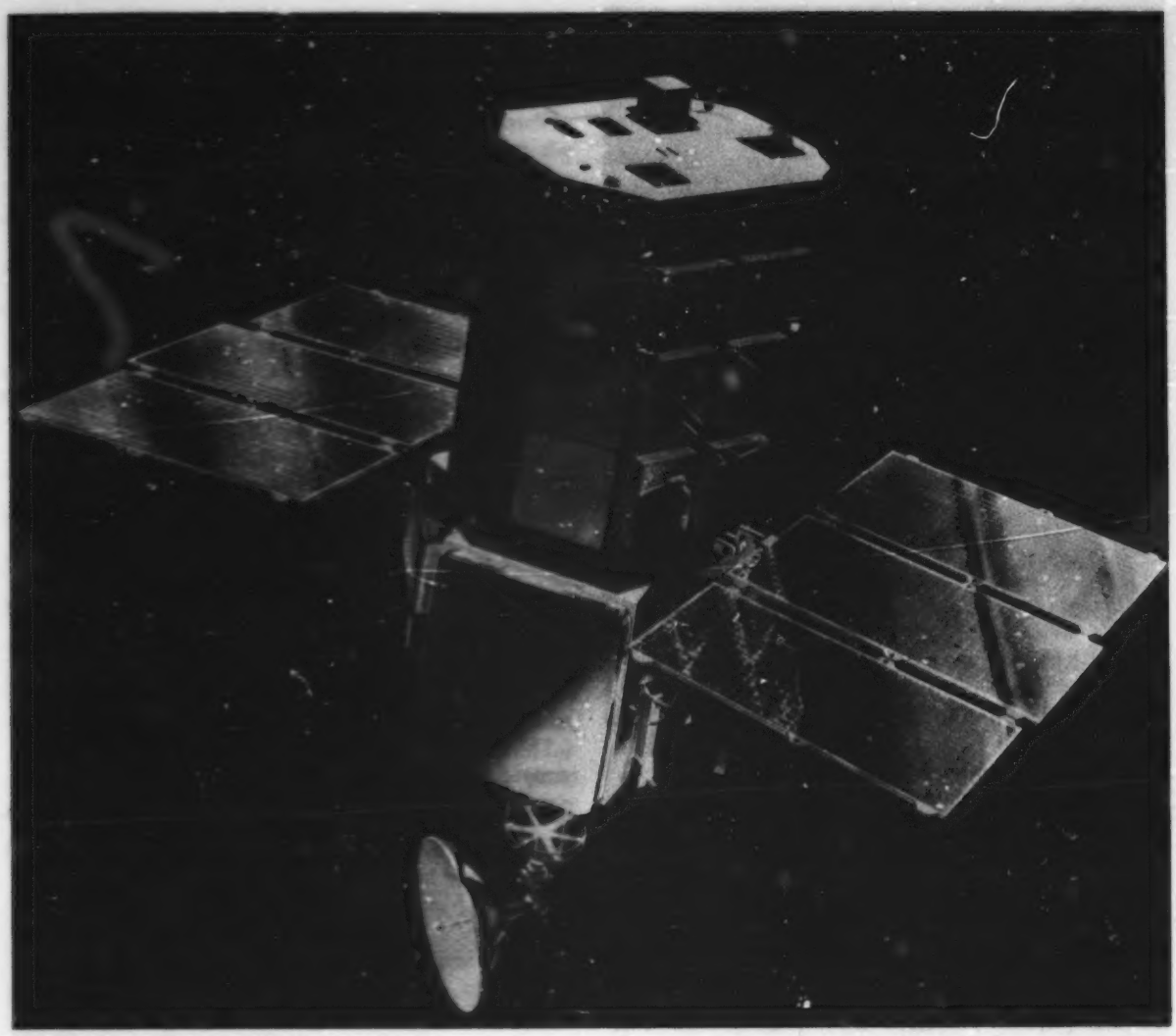
The Spacecraft. The SMM spacecraft was built on the modular concept. Its scientific instruments can be easily replaced or refurbished by either changing the experiment module or changing instruments within the experiment module. The eight-sided observatory is powered with solar panels and fitted atop a modular spacecraft base.

It is the first satellite equipped with a grapple so it can be retrieved in Earth orbit by the Space Shuttle's robot arms and brought back to Earth. If the Shuttle astronauts retrieve the SMM in late 1982, it can be used all over again.

The Experiments. The observatory's complement of six well-matched experiments span the spectrum from visible light through ultraviolet, infrared, x-ray, and gamma ray allowing scientists to monitor the active regions with their associated sunspots, and focus on flares.

An ultraviolet spectrometer-polarimeter will provide sharp pictures, well-resolved spectra, and measurement of velocities and strong magnetic fields in flares. A visible light coronograph/polarimeter will trace coronal effects of flares that sometimes put a major fraction of their energy into plasmas ejected into interplanetary space.

The experiments were designed to meet the following objectives: (1) to observe flare and flare-induced effects in the Sun's chromosphere, chromosphere-corona transition region, and corona; (2) to determine the fundamental characteristics of the solar plasma before, during, and after solar flares; (3) to study coronal evolution at the period of solar maximum activity point; (4) to determine the temperature and density structure of the high energy flare plasma as a function of space and time; (5) to investigate the position, structure, and thermodynamic



Solar Maximum Mission spacecraft.

properties of hot thermal and non-thermal sources in flares; and (6) to investigate electron acceleration and very high temperature plasmas by observing high energy solar x-rays and gamma rays.

A seventh experiment, a total solar irradiance monitor, will measure the solar constant to an accuracy of ± 0.1%.

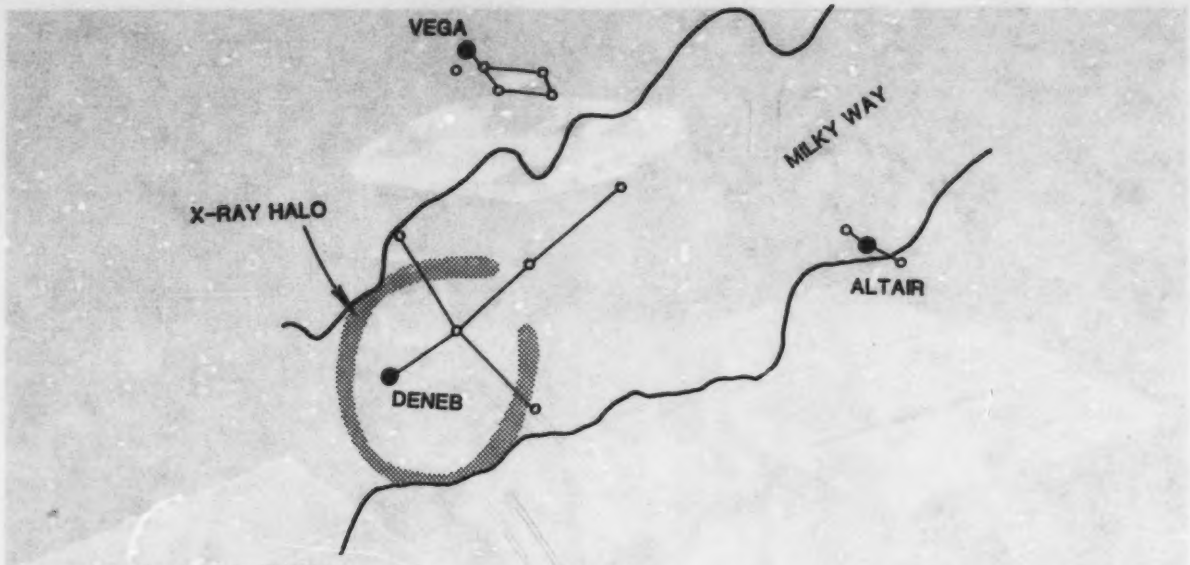
Why Solar Research. The Sun literally controls the behavior of the Earth's atmosphere and provides a continuous source of energy necessary to support life on Earth. Thus, it affects our weather, climate, communications, and environment in fundamental ways.

The ultraviolet and x-rays emitted by the Sun are responsible for the terrestrial ionosphere, which is vital to long-distance radio communication. Solar ultraviolet radiation also produces the terrestrial ozone layer, which absorbs ultraviolet light and prevents it from reaching the surface of the Earth. Without its protection, life as we know it would be difficult or impossible.

Therefore, it is of considerable practical interest to monitor the Sun for disturbances and attempt to predict them.

This solar maximum period is expected to be the second most active since Galileo discovered sunspots. The greatest recorded activity on the Sun was during the solar maximum of 1957, when more than 200 sunspots were recorded in September of that year. The last solar maximum, in 1968-69, was relatively quiet.

SMM is expected to operate throughout the peak of the current maximum in solar activity. Because of the new telescopes, remote-sensing instruments, and spacecraft that were not generally available during past solar maxima, the 1980 Solar Maximum Year will be the most widely scrutinized in history.



The x-ray halo discovered by HEAO 1.

The High Energy Astronomy Observatories

HEAO 1. X-ray data from NASA's High Energy Astronomy Observatory (HEAO) 1 has revealed a superhot, gigantic glowing bubble of gas some 6,000 light years away from Earth and some 1,200 light years in diameter. It is centered in the summer constellation Cygnus, the Swan, which includes the Northern Cross.

A halo of gas, the "superbubble" has a temperature of two million degrees C (3.5 million F), enough to create 10,000 new stars like our Sun, and its energy output in any given instant is equal to ten times the amount of energy emitted by our Sun during its lifetime.

Scientists are puzzled about how this huge amount of energy got locked up in this enormous ring. There are very few astrophysical processes in the Galaxy capable of supplying so much energy. The most powerful explosion known to astronomers is that of a supernova, an exploding star, but a supernova releases only about three percent of the energy needed to make the superbubble. One theory suggests that about three million years ago a supernova exploded with such force that it blew against the large interstellar cloud known as the Great Rift of Cygnus; this dark cloud has enough material to make five million stars and lies right next to the observed superbubble. The force of the explosion compressed the cool gas of the Rift and caused the formation of perhaps 1,000 stars of which about ten would become supernovas. These ten stars would explode in turn, and, pushing against the cloud, cause more stars to form as the compression on the cloud continued. The explosions created a shell or bubble of superheated gas that became the immense bubble discovered by the HEAO 1 x-ray data.

Only parts of the huge halo had been seen before. Thus no one knew what was being observed. One part, for example, was thought to be a supernova remnant, while another part was believed to be hot gas escaping from the Galaxy. Because of its large size, the halo was not seen in its entirety until it could be picked up in the x-ray sweep provided first by HEAO 1.

The spacecraft, which conducted an all-sky survey and mapped about 1,500 x-ray sources, burned up as it reentered the Earth's atmosphere in March 1979.

HEAO 2. HEAO 2, popularly known as the Einstein Observatory, has been given an extension beyond its projected 11-month mission.

Launched in November 1978, its performance has been excellent and four of its five scientific instruments continue to work satisfactorily. The early results have been significant and the observatory, which carries the largest x-ray telescope ever built, will continue to search the skies for information about such objects as quasars, pulsars, exploding galaxies, and black holes.

A continuing activity with the observatory is NASA's Guest Investigator Program. Principal investigators develop the instruments and use them during the planned lifetime of the spacecraft. After that, guest investigators use the satellite data for studies not directly related to the planned objectives. Since the launch of HEAO 2, about 400 guest investigator proposals have been received by NASA from more than 80 groups in the United States and other countries.

Correction

On the third page of the Fall 1979 issue of *NASA Report to Educators,* the description of the complicated streaks on the surface of Jupiter's satellite Europa included a typographical error. The depth of the streaks is 91 m (300 ft), not 91 km.

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1980 Launch Schedule

On January 17 at 8:26 p.m. the first launch of the eighties was "near perfect," the lift-off of an Atlas-Centaur vehicle that took aloft the third FLTSATCOM (Fleet Satellite Communications) satellite. Described as spectacular, the launch for the Department of Defense (DOD) from Cape Canaveral, Florida, successfully placed the satellite in an orbit designed to serve worldwide U.S. defense communications.

This first success of the new year was followed by the SMM launch in February. Other launches on the 1980 schedule, all reimbursable by other organizations, are: two Intelsat V communications satellites for Comsat in September and December; two for NOAA (National Oceanic and Atmospheric Administration), a weather satellite in May and a Geostationary Operational Environmental Satellite (GOES) in August; two Transit navigation satellites for the DOD in July and October; a Satellite Business Systems spacecraft in October; and another FLTSATCOM in November.

Competition for Student Science Experiments in Space

Early in February NASA issued a request for proposals for the administration of a Shuttle Student Involvement Project. The project will be a nationwide competition for secondary school students, to begin in September 1980, for the opportunity to submit proposals for scientific and engineering experiments to be flown on the Space Shuttle in late 1981 or 1982.

Working with NASA officials, the contractor will formulate rules for the secondary school competition and define ten regions from which semifinalists will be selected. The contractor also will devise entry/application forms and project rules and manage the actual competition.

The competition will be conducted so that entries in the ten regions will be selected (20 per region) in a semifinalist competition. Winning entrants from the regional competition will meet to discuss their proposals. Following the regional seminars, up to ten proposals in each region will be selected for final judging. From these approximately 100 regional selections, 20 winning entries will be chosen. NASA will retain the final decision as to whether or not an experiment flies aboard the Space Shuttle.

In addition, NASA will attempt to match student proposers with industrial or other non-NASA sponsors who will support the development and post-flight analysis of student experiments. NASA may also agree to provide assistance to individual winners in the event that no industrial/institutional support can be found.

Prior to any development work, students whose proposals have been selected for flight and their institutional/industrial advisors will attend a seminar at the Kennedy Space Center, Florida, to discuss their

January 17, 1980—first launch of the decade.

projects with other students, professional scientists, and NASA officials.

NASA's program to involve the nation's secondary school students in creative scientific activity began with participation in science fairs in 1961. The best known of the student involvement projects is the competition held prior to the Skylab mission which led to the selection of 19 experiments for flight aboard the spacecraft.

The primary difference between the new project and earlier competitions is that the Shuttle Student Involvement Project is planned as an annual program rather than a one-time-only event.

Science Talent Institute

The 1980 Science Talent Institute supported by the Westinghouse Educational Foundation and Westinghouse Electric Corp. and administered by Science Service was held in Washington in late February. The group included **Mark William Turner** of Niceville, FL, a NASA award-winner at the 1979 International Science and Engineering Fair.

A highlight of the annual program is the opportunity for the 40 finalists to meet professional personnel in nearby universities and government agencies. Nine of the students visited NASA's Goddard Space Flight Center. Among them was one of the top $12,000 scholarship winners, **Lisa Joy Randall** of Fresh Meadows, NY; **Bryan Edward Penprase** of San Marino, CA, recipient of a $7500 scholarship; and **Brian Randolph Greene** of New York City, who was named first alternate. Dr. Hans Mark, Secretary of the Air Force and former director of the NASA Ames Research Center, addressed the group at the awards banquet.

1980 National Aviation/Space Education Convention

The American Society for Aerospace Education (ASAE) and the National Council for Aerospace Education are planning the second National Aviation/Space Education Convention, July 21-25, at the Florida Institute of Technology, Melbourne, Florida, and the NASA Kennedy Space Center (KSC).

The convention program includes two Special Days—one, Space Center Day, will be a tour of KSC, emphasizing the Space Shuttle; the other, Sport Aviation Day, will include lectures, exhibits, and an air show, all involving a variety of air vehicles.

In addition, Convention '80 will present aviation and space speakers; extensive exhibits on aviation and space education; elementary, secondary, and higher education sessions; a meeting for workshop directors; representatives from every major National Aviation and Space Education Program; and the 37 Annual Aerospace Education Awards Banquet.

Full-time registrants to the convention are limited to 500. Registration is $35.00 for ASAE members, $50.00 for non-members; room and board is $17.00, double occupancy, for lodging and three meals per day. For more

Science Talent Institute participants at the Goddard Space Flight Center.

information, contact ASAE, 1750 Pennsylvania Avenue, NW., Washington, DC 20006.

Teacher's Guides for Aeronautics and Space Reports

Five new teacher's guides have been prepared for NASA *Aeronautics and Space Reports*, 4½-minute "mini-documentary" films with color and sound. Produced monthly for television, the film subjects deal with all of NASA's major efforts in both space and aeronautics.

A limited number of the film clips and guides is available from the Film Loan Office at the NASA Center serving your state (see p. 8): *Aeronautics and Space Report* **#172,** *Voyager I . . . Early Results;* Subject: Language arts, geography. **#175,** *Wind Power;* Subject: Language arts, social studies, science, math. **#176,** *Space Shuttle Tiles;* Subject: Language arts, social studies, science, math. **#178,** *Aeronautics and Space Highlights 1979.* **#179,** *The Flight Directors;* Subject: Language arts, social studies, science, math, career education.

Bibliographies Available

For Earth science teachers and others interested in environmental education and energy education, NASA has printed the following listings of non-technical materials: "NASA Publications, Films, and TV Programs for Earth Science and Environmental Education" and "NASA Publications, Films, and TV Programs for Energy Education."

Copies of either or both bibliographies may be obtained by writing to the Community and Education Services Branch (LFG-9), NASA, Washington, DC 20546.

Staff Changes at the Lewis Research Center

Calvin W. Weiss, Educational Programs Officer for the NASA Lewis Research Center since their educational staff was established in 1962, retired in December 1979.

As chief of Educational Services, Mr. Weiss worked closely with the educational community and general public in coordinating NASA services within the six-state area served by the Center.

Under his aegis the annual on-Center workshop for teachers sponsored by Baldwin-Wallace College and Kent State University was established and the Visitor Information Center (VIC) built. Mr. Weiss envisioned and supervised the design and construction of the VIC, which has welcomed some 250,000 visitors since opening in 1978. A Teachers Resource Room, created as part of the VIC, has been acclaimed for the equipment and services it provides for teachers throughout the area.

Mr. Weiss' retirement plans include lecturing at Cuyahoga Community College and participation in the American Aviation and Great Lakes Historical Societies and the Academy of Model Aeronautics.

Harrison Allen, Jr. has been appointed Chief of the Lewis Center's Educational Services Office. Mr. Allen joined the LeRC staff in 1952. Author of many NACA/NASA technical papers, he holds a U.S. Patent on the ignition of solid propellant rocket motors.

A graduate of Cleveland State University where he received a Bachelor of Science degree, Mr. Allen has attended graduate school at Case Western Reserve University. Prior to his appointment as educational officer, he served as Assistant Technology Utilization Officer for the Center and represented the office at several aerospace education workshops and community programs.

Recent NASA Publications

Chariots for Apollo: A History of Manned Lunar Spacecraft, SP-4205, is NASA's narrative history of the Apollo spacecraft, tracing its development and eventual successful completion of its mission, to carry men to the Moon and return them safely to Earth before 1970. The story begins with the creation of NASA and ends with Apollo 11, the first of six missions to land men on the Moon. Paperbound, 550 pp. $9.00 (Stock No. 033-000-00768-0).

Space Resources and Space Settlements, SP-428, is a compilation of technical papers resulting from the 1977 Ames Summer Study on Space Settlements and Industrialization Using Nonterrestrial Materials. Directed by Gerard K. O'Neill of Princeton University, the study was the largest and most comprehensive investigation of space manufacturing and habitation to date. Paperbound, 300 pp. $6.50 (Stock No. 0-293-364).

Galileo to Jupiter is a 20-page booklet describing Project Galileo, which will be the first mission to use the space shuttle as an interplanetary launch vehicle. It tells the story of Galileo's discovery of Jupiter's moons and outlines the mission in detail. $2.50 (Stock No. 033-000-00763-9).

The Space Shuttle at Work, EP-156, describes the Space Shuttle, its development and components, with a brief description of the uses of space and future possibilities for the Shuttle. 76 pp. $3.75 (Stock No. 033-000-00779-5).

The above publications are available from the U.S. Government Printing Office, Washington, DC 20402.

Where to Write for Services

NASA publications should be ordered from the Superintendent of Documents, Government Printing Office, Washington, DC 20402. Publication lists, film lists, and information about other services are available from the Educational Office at the NASA center serving your state. See the list below. There are special resource centers for educators at the Kennedy Space Center, Lewis Research Center, and Alabama Space and Rocket Center, Huntsville, AL.

NASA Ames Research Center
Moffet Field, California 94035
Alaska, Arizona, California, Hawaii, Idaho, Montana, Nevada, Oregon, Utah, Washington, Wyoming

NASA Goddard Space Flight Center
Greenbelt, Maryland 20771
Connecticut, Delaware, District of Columbia, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont

NASA Lyndon B. Johnson Space Center
Houston, Texas 77058
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Kennedy Space Center, Florida 32899
Florida, Georgia, Puerto Rico, Virgin Islands

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Kentucky, N. Carolina, S. Carolina, Virginia, West Virginia

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Illinois, Indiana, Michigan, Minnesota, Ohio, Wisconsin

NASA George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812
Alabama, Arkansas, Iowa, Louisiana, Mississippi, Missouri, Tennessee

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The Administrator of the National Aeronautics and Space Administration has determined that the publication of this periodical is necessary in the transaction of the public business required by law of this Agency. Use of funds for printing this periodical has been approved by the Director of the Office of Management and Budget through December 31, 1981.

NASA REPORT TO EDUCATORS is published four times per year for the community of educators, especially at the elementary and secondary school levels. Contributions and recommendations are solicited from readers, and should be addressed to the Community and Education Services Branch, Public Affairs Division (LFG-9), National Aeronautics and Space Administration, Washington, D.C. 20546. Photocopying for school use is approved.

NASA Report to Educators
Vol. 8, No. 1 Spring 1980

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Report To Educators

Vol 8, No. 2 Summer 1980

Voyager Pictures Used to Map Jovian Moons

The results of the Voyager 1 and 2 encounters with Jupiter last year continue to fascinate. A major step in accurately mapping the planet's four large moons has been completed by the Rand Corp. based on photographs from the spacecraft.

Using many of the 33,000 pictures of Jupiter and its Galilean satellites taken by Voyager 1 in March 1979 and by Voyager 2 in July 1979, the Rand staff has put together geodetic control networks that will be used internationally by astronomers and planetary scientists in making and using maps of the bodies. Geodetic control networks are used to compute geographic coordinates of features on the surface. They are also used to determine latitudes and longitudes for preparation of maps.

Jupiter and its Galilean satellites shown, not to scale but in their relative positions: Io (upper left) is nearest Jupiter; then Europa (center); Ganymede (lower left); and Callisto (lower right).

In addition to the new control networks, accurate radii of the four satellites—Io, Europa, Ganymede, and Callisto—have been established:

Io = 1,816 ± 5 kilometers (1,128 ± 3 miles)
Europa = 1,563 ± 10 km (971 ± 6 mi)
Ganymede = 2,638 ± 10 km (1,639 ± 6 mi)
Callisto = 2,410 ± 10 km (1,497 ± 6 mi)

Control networks for the satellites contain: Io, 307 points, 159 pictures; Europa, 86 points, 46 pictures; Ganymede, 227 points, 71 pictures; Callisto, 291 points, 95 pictures. The control networks and resulting maps will help astronomers and planetary scientists to maintain an accuracy never before possible.

Voyager's narrow-angle camera gives a 1 km (0.62 mi) resolution from a distance of 50,000 km (31,000 mi). Closest approaches to the satellites were as follows:

Io—Voyager 1 distance, 20,570 km (12,782 mi)
Voyager 2 distance, 1,129,900 km (702,087 mi)
Europa—Voyager 1 distance, 733,760 km (455,937 mi)
Voyager 2 distance, 205,720 km (127,828 mi)
Ganymede—Voyager 1 distance, 144,710 km (89,918 mi)
Voyager 2 distance, 62,130 km (38,605 mi)
Callisto—Voyager 1 distance, 126,400 km (78,541 mi)
Voyager 2 distance, 214,930 km (133,551 mi)

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Saturn photographed by Voyager 1 on March 20, 1980.

Voyager 1 and Saturn

Still several months from its rendezvous with Saturn, Voyager 1 has taken a photograph of the ringed planet that promises pictures at the encounter to rival the extraordinary views of Jupiter obtained last year.

The spacecraft took this photograph on March 20 at a distance of 312,270,000 kilometers (194,400,000 mi). The picture was computer-enhanced to bring out the rings and other features. One of Saturn's moons, Rhea, can be seen at lower left.

Voyager 1 will make its closest approach to Saturn on November 12 this year; Voyager 2 will fly past in August 1981.

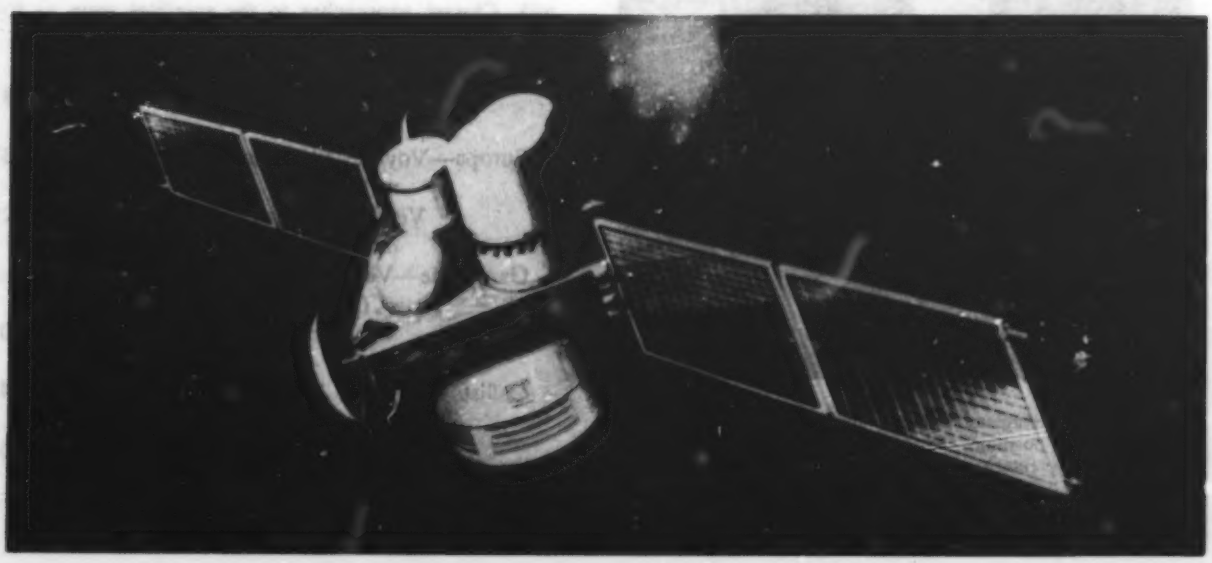
Gamma Ray Observatory

Designs are being created for a Gamma Ray Observatory (GRO) space astronomy mission. The observatory will weigh more than 11,000 kilograms (22,000 lbs) and is expected to carry five large gamma-ray instruments requiring sustained pointing at gamma ray sources in space. The spacecraft system will provide attitude control, power, and command-communications systems to support the scientific instruments.

Gamma ray astronomy is providing fundamentally new information about stars, the galaxy, and the universe. Gamma rays are one of three kinds of radiation emitted by radioactive substances, and their ability to penetrate matter is high. Their energies range from 5 to 13 electron volts. The rays are produced in many ways; one is that cosmic rays interact with gases, dust, and magnetic fields that exist between stars, producing gamma radiation. The gamma rays can therefore be used to trace and map the distribution of cosmic rays and gas in the galaxy.

Until the 1940s, virtually all astronomical knowledge was derived from the very narrow portion of the electromagnetic spectrum called the "optical window," the range of frequencies to which our eyes are sensitive. After World War II, largely as a result of technical developments in the radar field, radio astronomy emerged. With the advent of orbiting satellites, the x-ray portion and then the infrared portions of the electromagnetic spectrum came under study by space vehicles.

The GRO is planned to be launched aboard the Space Shuttle in the mid-1980s, and to be capable of being retrieved at a later time. Its expected mission life is about two years.



Artist's concept of the Gamma Ray Observatory.

The *Gossamer Albatross* crossing the English Channel.

NASA and the Gossamer Albatross

The world welcomed a new hero to aviation history on June 12, 1979, when Bryan Allen successfully pedaled the *Gossamer Albatross* across the English Channel. He shared accolades with Dr. Paul MacCready, designer of the aircraft that was powered by human muscle. For 2 hours and 49 minutes, Allen pedaled the *Albatross* 37 km (23 mi) to make it the first human-powered aircraft to cross the Channel.

The flight followed specific rules: The craft had to be heavier-than-air, takeoff had to be from the ground, the only power source allowable was human muscle with no assists of any kind. The points of takeoff and landing could be anywhere on the English and French mainlands, but the flight had to be continuous, and no part of the craft could be jettisoned in flight. The pilot could fly as low to the water as necessary but no higher than 48.8 meters (160 ft) to prevent gliding to France.

Allen's flight was accompanied by a rescue boat, which was nearly called into service. Among the problems encountered was a strong headwind that caused the craft to lose altitude, at one point coming within 15 cm (6 in) of the water. Allen signaled for the rescue boat, but as he was climbing to allow room for it, he found smoother air. He waved the boat away and continued his flight to its place in history.

Unusual design concepts—a huge wingspan and low weight that give the craft extremely high lift and an ability to fly slowly—intrigued NASA scientists. The aerodynamic characteristics, unlike those of any other aircraft, offered an opportunity for basic research in an area of aerodynamics that has been virtually unexplored, the regime of very low speed and low Reynolds number flight.

Thus NASA conducted a flight-test program this Spring to study more fully the aerodynamics of the *Albatross*—not with the one that flew the Channel, but with a twin, the *Gossamer Albatross 2*. During the six-week program 17 actual data-gathering flights and ten other flights were flown as part of a joint program of NASA's Dryden Flight Research and Langley Research Centers.

Not only was an historic aircraft documented, but its performance—exactly how much power it takes to

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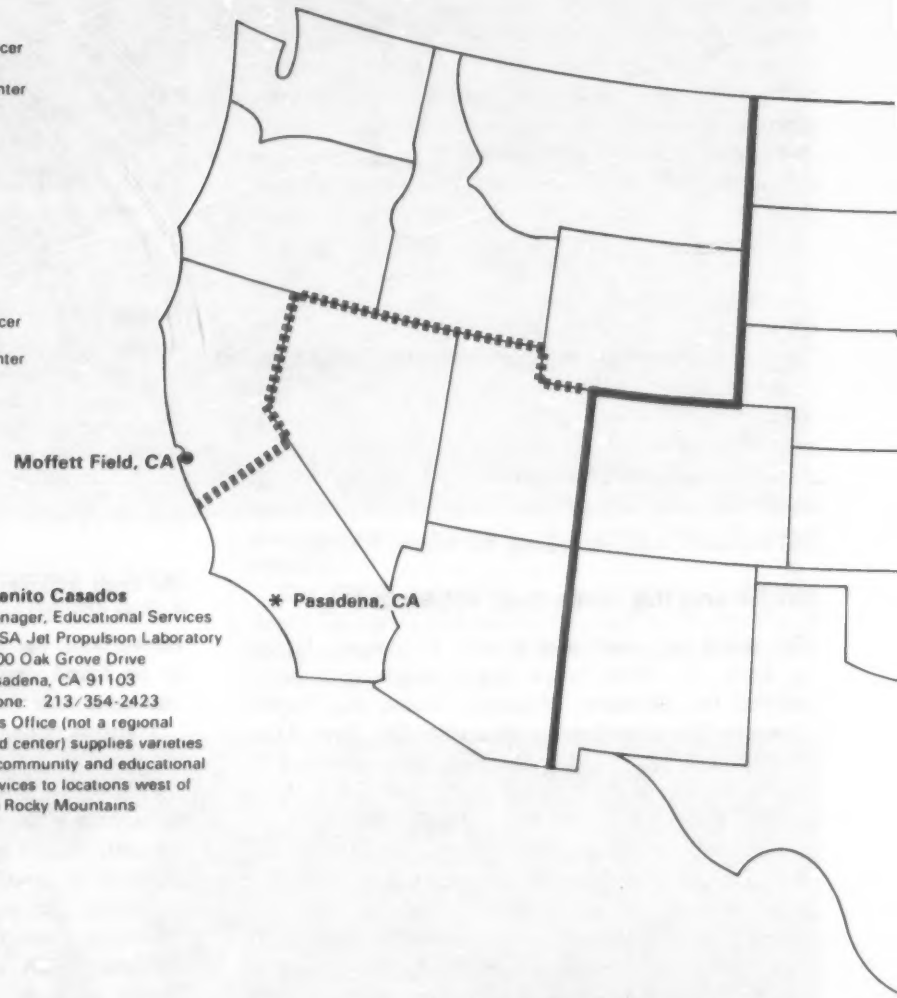

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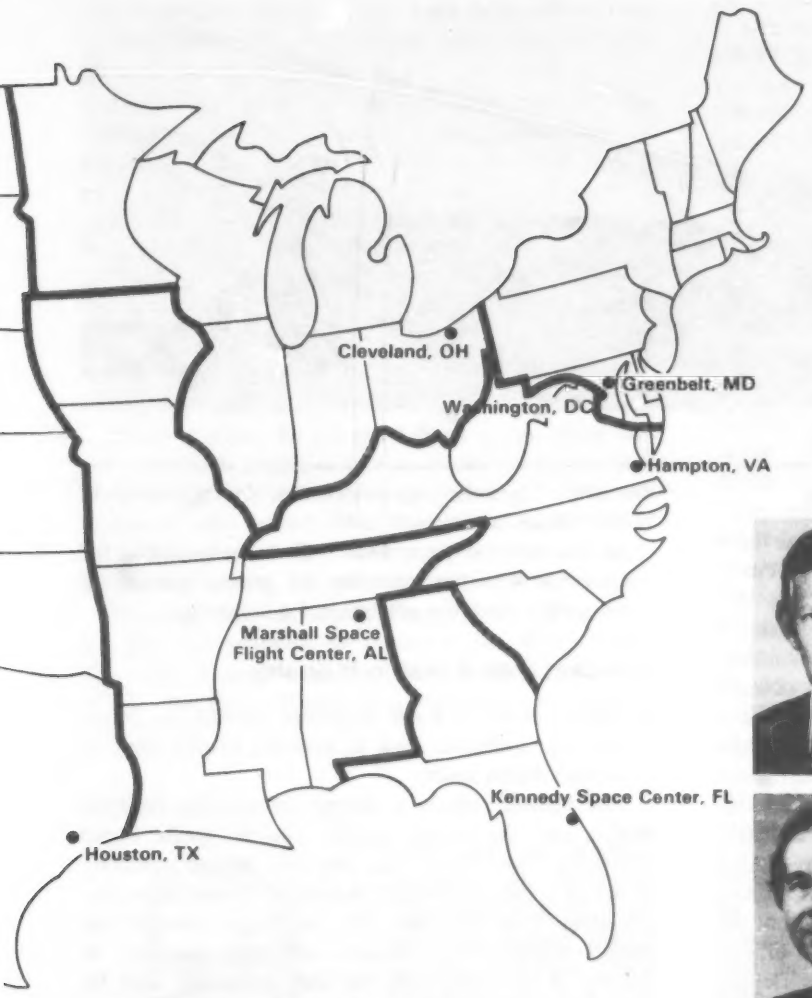
William D. Nixon
Assistant Chief



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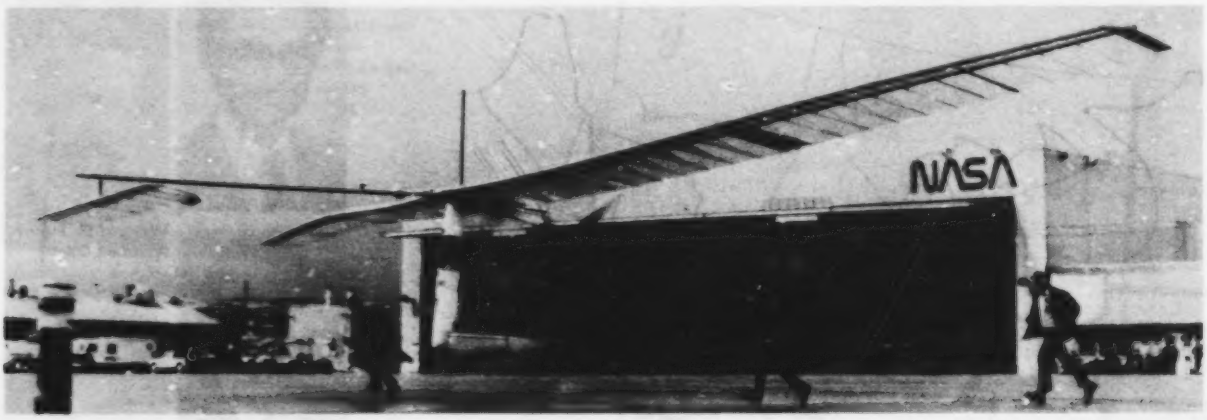
fly the craft in various flight conditions with altitude and atmospheric turbulence important test factors. The lightweight craft was flown using human power, as with the *Albatross 1;* a small electric motor; and towed with the propeller removed. It carried a miniaturized instrumentation system.

Results from the program are being analyzed to study the unusual aerodynamic, performance, stability, and control characteristics of large, lightweight, low speed aircraft for possible application to future high altitude craft. Final results will be documented and published, probably early in 1981.

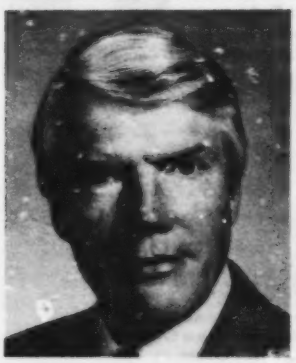
Gossamer Albatross specifications:

Span:	93′10″ (Canard 18′4″)
Chord (root):	5′6″ (Canard 3′6″)
Chord (tip):	3′11″
Sweep:	7°30′
Prop. Diam:	13′6″
Pitch:	12′ approx.
Wing Area:	472 squ. ft.
Canard Area:	64.2 squ. ft.
Weight:	70 lbs. approx.
Area Loadings:	7.25 oz/squ. ft. (wing only)
	6.4 oz/squ. ft. (total area)



Gossamer Albatross 2 during the flight-test program.

New NASA Director of Public Affairs



Brian M. Duff has been named Director of Public Affairs for NASA. He brings to the Agency's Headquarters in Washington over 17 years of management communications and media services experience, including ten years of government public affairs experience.

Duff returns to NASA from the position of Managing Director, Public Affairs, at Amtrak in Washington where he supervised the headquarters public affairs staff and three field offices. Prior to that position, he served two years as Deputy Assistant Secretary for Public Affairs at the Department of Health, Education, and Welfare.

Duff was previously employed by NASA at the Johnson Space Center, Houston, where he directed the full range of public affairs activities during a period of intense space flight activity, including the first landing on the Moon. He also spent five years at NASA Headquarters as Director of the Special Events Division, where he was responsible for a variety of public affairs activities.

In his new position, Duff will be responsible for agencywide activities involving the general public, the news media, and the educational community.

Landsat 3 an Asset to Industry

NASA's Landsat 3 Earth resources satellite has found a new use: gathering data to improve management of America's forest lands.

The project reflects a unique relationship between NASA and the private sector. The St. Regis Paper Company, New York, was the first private company to act as a user in NASA's Resource Observation Applications Test Program. The St. Regis initiated the project—rather than NASA—and the company is sharing in the total cost, but the technology will be available to all other timber companies.

Since 1977, St. Regis has been working with NASA in a test program to see if Landsat data could improve the paper industry's information base on forest lands. St. Regis wants to use the data for planning timber harvests, leasing and buying new timber lands, and to monitor more than 920,000 hectares (2.3 million acres) across the South.

The project has been so successful that a St. Regis Division in Jacksonville, FL, recently authorized a new investment in a forest resource information system to use Landsat data to supplement conventionally acquired data. St. Regis will use techniques developed in the project at its Dallas, TX, computer facility to process the data coming from Landsat which will complement the automated data base at its divisional remote sensing center in Jacksonville. The combined data will assist the company in estimating timber volume and productivity, as well as changes in the conditions of the forests. Landsat data will be used to determine distribution of the major types of trees on St. Regis-owned timberland and other land available through lease or purchase.

The entire forestry industry stands to gain from the venture because technology developed by the St. Regis experiment is in the public domain and available to other companies. The company and NASA plan to conduct a symposium in 1981 to demonstrate Landsat interpretation methods to timber industry managers.

The project is being conducted by NASA's Johnson Space Center, Houston; the Laboratory for Applications of Remote Sensing at Purdue University, Lafayette, IN; and the St. Regis Paper Co. It is scheduled to end in September of this year.

Landsat orbits the globe 14 times a day at an altitude of 900 km (560 mi). Its electronic multispectral scanner returns data which is processed into film and computer tape format. This resource information may be used to characterize different types of terrain, vegetation, soils, rocks, and other surface features.

Quarterly reports on the Applications Pilot Test Program are available for review at the NASA Scientific and Technical Information Facility, P.O. Box 8767, Baltimore/Washington International Airport, MD 21240.

NCAE Award

Each year the National Congress on Aerospace Education (NCAE) selects outstanding educators for its Crown Circle Certificate award. Among the 1980 recipients honored by NCAE for "Evidence of a lifetime of performance demonstrating the zenith of leadership in aerospace education" was **Calvin W. Weiss,** a member of the NASA Lewis Research Center (LeRC) staff for 36 years. In 1961 when LeRC established an educational office, Mr. Weiss was chosen to head the new program and climaxed his long career at the Center as Chief of Educational Services.

NASA Educational Briefs

A new series of educational publications for secondary classrooms has just been published, *NASA Educational Briefs* (EB). The briefs, from one to four pages in length, cover general science and engineering topics pertinent to NASA programs and include "Questions For Discussion" with your students.

The subjects of the first five briefs published are: **EB-80-1,** *What Color is the Sky?;* **EB-80-3,** *Exploring the Inner Planets (Mercury, Venus, Earth, Mars);* **EB-80-4,** *Great Jupiter;* **EB-80-5,** *Exploring the Outermost Planets (Saturn, Uranus, Neptune, Pluto, and ?);* **EB-80-6,** *The Electromagnetic Spectrum.* Announcements of **EB-80-2**, *Some Figures on the Planets,* and other briefs will be made as they are published.

The briefs are available from the Community and Education Services Branch (LFG-9), NASA, Washington, DC 20546.

Career Information

Another new series of publications is *Careers in Aerospace,* nine aerospace career profiles. Each profile includes a description of the work performed, qualifications needed, preparation and training, job prospects, related fields, and sources of additional information. The titles: *Aerospace Engineer, Aerospace Engineering Technician, Astronomer, Geographer, Geologist, Ground Radio Operators and Teletypists, Meteorologist, Patternmaker and Molder,* and *Test and Research Engineer.*

The publications are available from the NASA educational office serving your state (see page 8).

Metric Height Chart for Elementary and Junior High School Classrooms

A *Metric Height Chart* that measures your students up to 200 cm is available for elementary and junior high school teachers. The chart, prepared for NASA by the National Metric Education Institute, includes information on metric distances (kilometers), mass (kilograms), and temperature (Celsius). It also lists the International Metric System of Units.

An astronaut and the Space Shuttle along with the Solar System and the planet Jupiter as seen by the Voyager spacecraft illustrate the chart. Single copies may be obtained from the Community and Education Services Branch (LEG-9), NASA, Washington, DC 20546.

Where to Write for Services

NASA publications should be ordered from the Superintendent of Documents, Government Printing Office, Washington, DC 20402. Publication lists, film lists, and information about other services are available from the Educational Office at the NASA center serving your state. See the list below. There are special resource centers for educators at the Kennedy Space Center, Lewis Research Center, and Alabama Space and Rocket Center, Huntsville, AL.

NASA Ames Research Center
Moffet Field, California 94035
Alaska, Arizona, California, Hawaii, Idaho, Montana, Nevada, Oregon, Utah, Washington, Wyoming

NASA Goddard Space Flight Center
Greenbelt, Maryland 20771
Connecticut, Delaware, District of Columbia, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont

NASA Lyndon B. Johnson Space Center
Houston, Texas 77058
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21000 Brookpark Road, Cleveland, Ohio 44135
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Marshall Space Flight Center, Alabama 35812
Alabama, Arkansas, Iowa, Louisiana, Mississippi, Missouri, Tennessee

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The Administrator of the National Aeronautics and Space Administration has determined that the publication of this periodical is necessary in the transaction of the public business required by law of this Agency. Use of funds for printing this periodical has been approved by the Director of the Office of Management and Budget through December 31, 1981.

NASA REPORT TO EDUCATORS is published four times per year for the community of educators, especially at the elementary and secondary school levels. Contributions and recommendations are solicited from readers, and should be addressed to the Community and Education Services Branch, Public Affairs Division (LFG-9), National Aeronautics and Space Administration, Washington, D.C. 20546. Photocopying for school use is approved.

NASA Report to Educators
Vol 8, No. 2 Summer 1980

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NASA National Aeronautics and Space Administration

Report To Educators

Vol. 8, No. 3 Fall 1980

The New Venus

A radar-mapper on the Pioneer Venus Orbiter has provided us with a stunning new look at the Morning and Evening Star. The spacecraft has been in orbit about the planet since December 4, 1978, and has mapped almost its entire surface. Venus' permanent cloud cover prevents direct photographic images, but the radar-mapper has returned data that has been interpreted by scientists and given form by an artist.

The Surface. Prior to Pioneer, less than one percent of Venus' topography had been measured by ground-based radar. With extensive radar data returned by the spacecraft, scientists have identified huge continent-sized features, a mountain as high as Mount Everest, and deep rift valleys.

The new data suggest that Venus' terrain and geology have both strong similarities to and major differences from those of any known planet. Its surface is gently rolling, with local dramatic highs. However, not counting Earth's oceans, Venus' range of elevations is somewhat greater than Earth's, ranging from 2,900 m (9500 ft) below the average radius of Venus' spherical surface to 10,800 m (35,400 ft) above that level.

Artist's conception of Venus' surface showing the planet's continent-sized highland regions—Ishtar Terra (top), Aphrodite Terra (foreground), and Beta Regio (left).

Topography Pioneer's radar-mapper measured Venus' surface deviations in topography from 75° north latitude to 63° south latitude. This covers 93 percent of the planet's surface, missing relatively small circular regions at each pole. (Because of temporary instrument failure, a mapping gap exists along 30° latitude. Pioneer is currently mapping this area.)

Sixty percent of Venus' surface is relatively flat, varying in height by only about 1000 m (300 ft) between high and low points. This huge, planet-encompassing plain lies at a 6050-km radius from the center of the planet (this radius describes a reference sphere, much as sea level does on Earth and all elevations refer to it).

About 16 percent of Venus' surface lies below the 6050-km mean altitude of the plain. Such low-lying regions are far more common on Earth (they are the ocean basins), occupying nearly two-thirds of Earth's surface compared to the one-sixth of Venus'.

Most of the remaining 24 percent are just a few thousand meters higher than the plain. Only eight percent of the planet is true "highlands." These highlands may resemble similar areas on Earth. They may be made of very light rock, and hence "float" much higher than other features.

Crust and Crustal Movements Although not as thick as those of Mars and the Moon, it now appears that Venus' crust is thicker than Earth's—so thick that it has choked off most crustal movement of plate tectonics. The lower layer of this crust apparently consists of heavier basalt-type rocks and wraps the entire planet. On top of this is a layer of light, granitic-type continental rock. (Russia's Venera 8 found the

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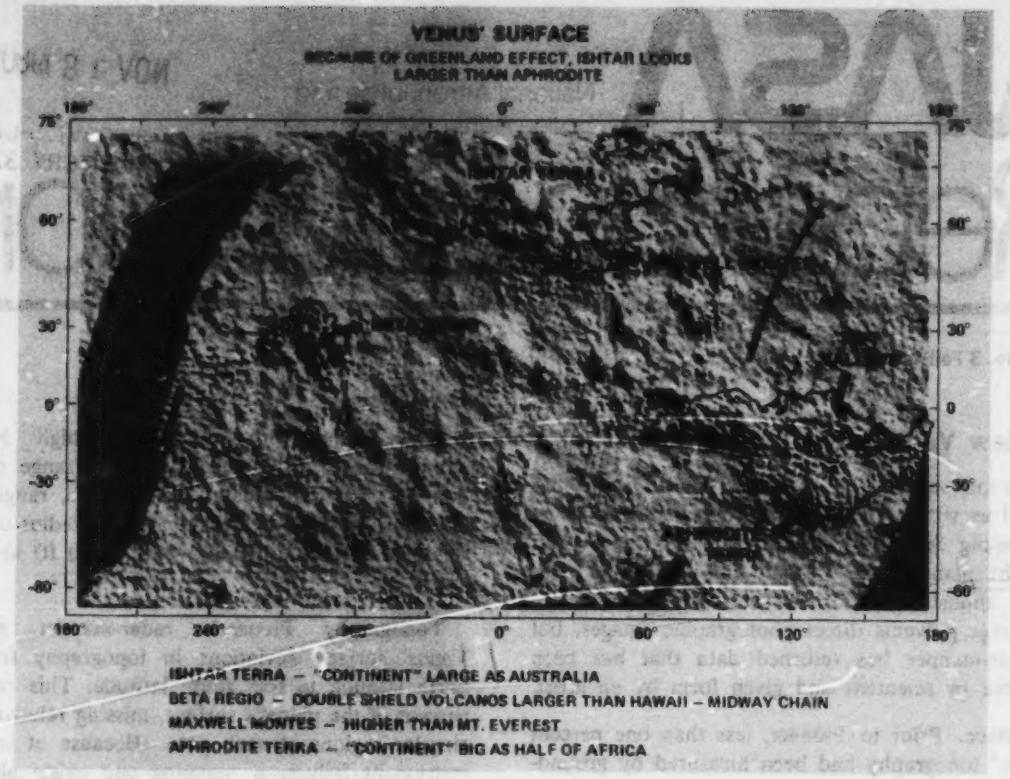

VENUS' SURFACE
BECAUSE OF GREENLAND EFFECT, ISHTAR LOOKS LARGER THAN APHRODITE
ISHTAR TERRA – "CONTINENT" LARGE AS AUSTRALIA
BETA REGIO – DOUBLE SHIELD VOLCANOS LARGER THAN HAWAII – MIDWAY CHAIN
MAXWELL MONTES – HIGHER THAN MT. EVEREST
APHRODITE TERRA – "CONTINENT" BIG AS HALF OF AFRICA

A Mercator projection of the surface of Venus from 75° north to 63° south latitude. The contour interval on the map is one kilometer.

radioactivity of rocks in one area of Venus' plains to be like that of granite.) This ancient layer of lighter rocks may form a single huge planet-girdling continent, covering about 84 percent of Venus' total surface. Perched on top of this giant continent are the smaller but still continent-sized highland regions.

Venus' crust apparently compresses one huge tectonic plate, compared with Earth's six major plates and several minor ones. (Due to continuous formation of new plate material, Earth's plates constantly expand and grind together.) On Venus, the low-lying basins comparable to Earth's ocean basins have no evidence of features similar to Earth's mid-ocean ridges, where molten basalt wells up to form new crust.

There appear to be abundant primordial impact craters like those on Mars and the Moon scattered over the surface of Venus. These craters have diameters above 75 km (45 mi), large enough for Pioneer to observe. Most of Venus' surface (and hence crust) appears to be ancient terrain. Atmospheric heating, water loss, and crust formation apparently took place in the first one - two billion years of the planet's history.

The Highlands. Venus has three continent-sized highland areas, which may be remnants of the last plate tectonic collisional zones, before crust formation choked off tectonics completely. Or, they may have resulted from local lifting forces (like those that created California's Sierra Nevada range).

Ishtar Terra The highest and most dramatic highland region on Venus is Ishtar Terra, named for the Assyrian goddess of love and war. About the size of Australia or the continental United States, it is a high plateau in the northern hemisphere with several mountain ranges and surrounded by steep escarpments.

The western part of Ishtar appears to be a smooth plateau; named Lakshmi Planum, it is about 3300 m (10,000 ft) above the global surface. Lakshmi is bounded on the west and north by mountains ranging upward from 2300 to 3300 m (7000 to 10,000 ft) above the plateau, and 5700 to 7000 m (17,000 to 20,000 ft) above Venus' surface. The western mountains have been named Akna Montes and the northern range, Freyja Montes. The Ishtar plateau is higher than Earth's Tibetan plateau and twice as large. Its central area is smooth in the radar images and may be covered with relatively young lavas.

Maxwell Montes The highest point yet found on Venus is a mountain massif higher than Everest named

Maxwell Montes after the 19th-century Scottish physicist, James Maxwell. This huge area of uplifted terrain occupies the entire east end of the Ishtar Terra highland. Its highest point is 10,800 m (35,400 ft) above the global surface and 9000 m (27,000 ft) above the adjoining Lakshmi plain.

The highest parts of the massif run northwest-southeast with lower projections extending both east and west. Observations from both Earth and Pioneer suggest that the mountain region itself is the roughest part of the planet with very broken up terrain changing abruptly from the smooth plateau west of it.

The steep slopes of Maxwell appear to be covered with rocks larger than 10 cm (25 ft). On its east flank, Pioneer data show a circular 100-km (60-mi) dark feature more than 900 m (3000 ft) deep which may be a volcanic crater. A complex topography of ridges and troughs extends for 100 degrees of longitude east of Maxwell.

Aphrodite Terra The largest of the highland regions on Venus has been named Aphrodite after the Greek goddess of love and beauty. Consisting of two mountainous areas separated by a somewhat lower region, it is as large as the northern half of Africa and lies almost parallel with the equator running east and west for 9600 km (6000 mi). Unlike Ishtar, a relatively level plateau carrying high mountains, the Aphrodite highland area rises to various heights: the western mountains are 8000 m (23,000 ft) above the surrounding terrain and 9000 m (27,000 ft) above the global surface; the eastern mountains rise 3300 m (10,000 ft) above the surrounding terrain, 4300 m (13,000 ft) above the surface. Radar imaging shows these two mountain ranges to be among the roughest and most broken up areas on the planet.

Like Ishtar, the region east of Aphrodite is also characterized by high ridges and deep valleys. Because Aphrodite does not appear to contain uplifted plateaus or volcanic mountains, this region may be older and more degraded than Ishtar.

Beta Regio Another highland area picked out by Pioneer is Beta Regio at 30° north latitude. It covers a north-south distance of 2900 km (1300 mi). Apparently consisting of two huge shield-shaped volcanoes larger than the Hawaii-Midway chain, each is about 4300 m (13,000 ft) above the plain. The northerly mountain has been tentatively named Rhea Mons and the southerly, Theia Mons. The two mountains have smooth surfaces and appear to be basaltic, and hence, very likely of volcanic origin. The Russian Veneras 9 and 10 landed just east of Beta and found the rocks there to be basalts.

Alpha Regio The fourth notable highland feature on Venus is Alpha Regio, a region rising some 1800 m

Artist's conception of Ishtar Terra with an outline of the continental United States superimposed.

(6000 ft) above Venus' great plain. About 25° south of the equator and 6400 km (4000 mi) west of Aphrodite, Alpha has extremely rough terrain with parallel fractures through the whole feature. It may combine old and new geologic forms and resembles the basin and range structure of the western United States.

Venus' Great Plain. Radar imaging of the relatively flat, rolling plain that covers 60 percent of Venus' surface shows many circular, dark features with bright central spots. These apparent craters with diameters of 400 to 600 km (250 to 320 mi) characteristically have depths of only 200 to 700 m (650 to 2300 ft). The bright, central areas could be the central peaks, typical of impact craters.

The very small depths and the very large diameters of these apparent craters, compared with the Moon and Mars, can be explained by "surface rebound" like that found on Jupiter's planet-sized moons. The apparent wide-spread cratering suggests that Venus' heavily-cratered ancient crust is preserved over much of the planet.

Lowlands. The largest low area found on Venus is centered west of Ishtar at 70° north. At its deepest point, this great basin is about 3000 m (9800 ft) below Venus' great plain. This low area, like others on the planet, is smooth and lacks large crater forms. It is about the same size as the North Atlantic Ocean basin and, like Earth's ocean basins, may be relatively young geologically and filled in by basaltic lava flows.

Rift Valley Venus' great Rift Valley lies at the east end of Aphrodite Terra. One of the lowest spots found on the planet, it is about 2,900 m (9500 ft) below Venus' global surface, slightly lower than the northern hemisphere basin. The right flank of the large mountain on the left side of the main rift valley descends to the bottom of the rift. This slope drops at an angle of about seven degrees—one of the steepest slopes measured on the planet.

The Rift is 280 km (175 mi) wide and 2250 km (1400 mi) long. It is deeper than Earth's Dead Sea rift, but only one-fifth the depth of the Marianas trench in the western Pacific. It is roughly the same depth as Valles Marineris, the great canyon on Mars.

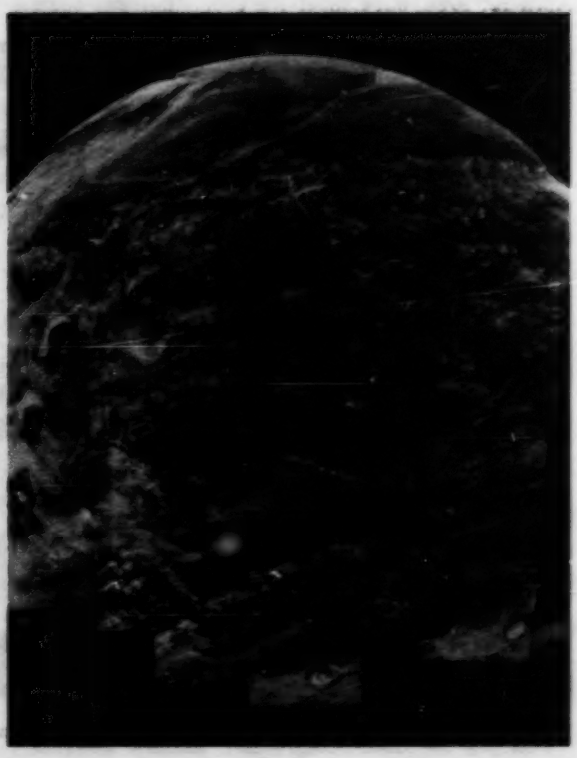
Future Images. The Pioneer Venus Orbiter is expected to continue receiving data for at least three years. An exciting prospect. The new data will refine the images already received and enhance the knowledge gained thus far. In time, Venus, like Mercury, Mars, and Jupiter, will become a familiar place with specific views. The mask of its clouds has been removed.

A Last Look at Mars

A clear day on Mars—Feb. 22, 1980—offered this extraordinary mosaic of 102 photos taken by Viking Orbiter 1. Among the last pictures taken of the planet, it shows several prominent, and now well-known, features. Valles Marineris, as long as the North American continent from coast to coast, stretches across the center. Three volcanoes of the Tharsis Ridge are at left (from south to north, Arsia Mons, Pavonis Mons, and Ascraeus Mons); all three are larger than any on Earth and two are higher than Mount Everest.

The picture also includes two remarkable sights, weather phenomena rarely seen. One is the sharp, dark line that curves north and east from Arsia Mons, which scientists believe is either a weather front or an atmospheric shock wave. This is the first time such a feature has been seen on Mars.

The second unusual weather activity is four tiny clouds in the southernmost frame. They are too close together to be resolved, even under high magnification, but in a large photograph their shadows cast on the planet surface can be separated easily. Judging from the distance between the clouds and shadows, the clouds float at an altitude of nearly 28 km (15 mi). The largest cloud is nearly 32 km (20 mi) long. Distinct cloud pattern shadows are rarely apparent on the face of Mars.



Project Viking

The thousands of pictures the Viking spacecraft have given us of Mars since 1976, in quantity and quality, have surpassed all expectation. And when the Viking Orbiter 1 was shut down on August 7 this year, it brought to virtual conclusion a mission successful beyond all dreams.

Viking was designed to orbit Mars and land and operate on its surface. Two identical spacecraft were launched in 1975—Viking 1 on Aug. 20, Viking 2 on Sept. 9. Each consisted of an orbiter carrying a sterilized lander.

Both were launched from Cape Canaveral and cruised through space for almost a year. Viking 1 began orbiting the planet June 19, 1976; Viking 2 on Aug. 7. The first landing occurred July 20 on the western slope of Chryse Planitia at 22.3°N, 48.0°W; the second on Sept. 3 at Utopia Planitia, 47.7°N, 225.8°W.

Viking's primary mission ended Nov. 15, 1976, 11 days before Mars passed behind the Sun. After conjunction in mid-December 1976, telemetry and command communications were reestablished, and the extended mission operations began. Orbiter 1 continued working until this summer. Orbiter 2 ended its mission in July 1978, when its attitude-control system ran out of gas. The last data from Lander 2 were received on April 12, 1980, but Lander 1 is programmed to operate through 1994, sending data consisting of meteorology information and pictures to Earth weekly.

Viking Results. Both Viking missions were glorious successes. With but one exception, the science instruments acquired more data than expected. Only the seismic experiment was a disappointment: the seismometer on Lander 1 could not be brought into operation after landing, and the other has detected only one event that may have been a Marsquake.

The three biology experiments discovered unexpected and engimatic chemical activity in the Martian soil, but no clear evidence of living organisms. The gas chromatograph/mass spectrometer found no sign of organic chemistry to its level of sensitivity, but it did provide a precise and definitive analysis of the composition of the atmosphere and found previously undetected trace elements. The elemental composition of the Martian soil has also been measured by the X-ray fluorescence spectrometer.

Measurements of some physical and magnetic properties of the soil have been made. The composition and physical properties of the upper atmosphere were also measured during the entry of the landers.

Nearly continuous monitoring of weather at the landing sites has been carried out. The weather in the Martian midsummer was found to be repetitious, but in other seasons it has become variable and more interesting. Cyclic variations in weather patterns (probably the passage of alternating cyclones and anticyclones) have been observed. Atmospheric temperatures at the southern landing site have been as high as –31°C (–24°F) at midday, with the predawn summer temperature being –86°C (–187°F). By way of contrast, the diurnal temperatures at the northern landing site during the midwinter dust storm varied as little as 4°C (7.2°F) on some days. The lowest predawn temperature was –124°C (–191°F), approximately the frost point of carbon dioxide. A thin layer of water frost covered the ground around Lander 2 during most of both the first and second winters.

The semiannual variation of barometric pressures resulting from condensation and sublimation of atmospheric carbon dioxide on the polar caps has been found to be unexpectedly large; the maximum and minimum mean daily pressures observed by Lander 1 were 6.8 and 9.0 millibars. Another surprise has been the generally small magnitude of wind velocities; neither lander has recorded a gust in excess of 120 km (74 mi) an hour, and mean velocities are much lower. Nevertheless, more than a dozen small dust storms have been observed by orbiter instruments. During the first southern summer, two global dust storms occurred, about four Earth months apart. Both obscured the Sun at the landers for a time and hid most of the planet from the orbiter cameras.

The infrared thermal mappers and the atmospheric water detectors on the orbiters have acquired data almost daily, observing the planet at high and low resolution. This massive quantity of data will require considerable time for analysis and understanding of the global meteorology of Mars. It was also definitely determined that the residual north polar ice cap that survives the summer is composed of water ice.

Analysis of radio signals from landers and orbiters, including Doppler, ranging and occultation data, and the signal strength of the lander-to-orbiter relay link has provided a variety of valuable information.

Viking Pictures. Photographs from the landers and orbiters continually surprised and delighted both scientists and public. The total number of pictures exceeds 4,500 from the landers and 52,000 from the orbiters. The landers provided the first close-up look at the surface, monitored variations of atmospheric opacity over a full Martian year, and determined the mean size of the aerosols. The orbiter cameras observed new and often puzzling terrain and provided clearer detail on known features, including some color and stereo observations, and mapped about 97 percent of the surface.

Other Discoveries. 1 Nitrogen, not previously detected, is a significant component of the Martian atmosphere, and the enrichment of the heavier isotope of nitrogen and argon relative to the lighter implies that atmospheric density was much greater in the distant past. 2 Changes in the Martian surface occur extremely slowly, at least at the two landing sites; only two very small changes were observed in four years. 3 The greatest concentration of water vapor in the atmosphere is near the edge of the north polar cap in midsummer. From summer to fall, the peak concentration moves to the equator, with about a 30 percent decrease in global abundance. In the southern summer, the entire planet is dry, probably also an effect of the dust storms. 4 The density of both Mars' satellites is low—approximately two grams per cubic centimeter—perhaps implying an asteroidal origin. The surface of Phobos is marked with at least two families of parallel striations, probably fractures caused by a large impact that may nearly have broken it apart. 5 Measurements of the round-trip time of passage of radio signals between Earth and the Viking spacecraft made while Mars was beyond the Sun (near the two solar conjunctions) have determined the amount of the delay of the signals caused by the Sun's gravitational field. The result confirms the prediction of Einstein to an estimated accuracy of 0.1 percent—twenty times greater than any previous test. 6 The atmospheric pressure varies by 30 percent during the Martian year because of the condensation and sublimation of atmospheric carbon dioxide in the polar caps. 7 The permanent north cap is water ice; the south cap probably retains some carbon dioxide throughout the summer. 8 Water vapor is relatively abundant only in the far north during the summer, but subsurface water in the form of perma-frost covers much if not all of the planet. 9 The northern and southern hemispheres are drastically different climatically because of the effect of global dust storms that originate in the south in the summer. 10 The Martian surface is a type of iron-rich clay that contains a highly oxidizing substance that releases oxygen when wetted. 11 The surface contains no organic molecules detectable at the parts-per-billion level. 12 No clear evidence of the presence of living microorganisms in the soil near the landing sites was discovered. The question of life on Mars remains open.

Viking in Perspective. NASA's exploration of the planet Mars by the Viking spacecraft was the culmination of a series of missions that began in 1964 with Mariner 4 and continued with the Mariner 6 and 7 flybys in 1969 and the Mariner 9 orbital mission in 1971 and 1972.

In its turn, the Viking Project has enhanced our view of and knowledge about Mars and its satellites immeasurably. Mars, Deimos, and Phobos have become familiar.

Viking's enormous success was a series of climaxes —new views from orbit, the excitement of the first landing, color pictures from the surface, initial findings, the surprisingly long-lived spacecraft. The data received from the experiments will occupy scientists for years to come. The pictures returned will be studied and analyzed with interest and fascination.

Its success has laid the groundwork, provided the hope, raised the expectation of future, more ambitious, missions. Viking has set new goals for the exploration of Mars.

Solar Flare "Hotline"

A "hotline" designed to inform the public of solar flares erupting on the Sun during this year's peak cycle of activity has been inaugurated at NASA's Goddard Space Flight Center in Greenbelt, MD.

The "Solar Max" hotline service is being provided jointly by NASA and the National Oceanic and Atmospheric Administration through the latter's Space Environment Services Center in Boulder, CO.

Information on sunspots, solar flares, geomagnetic storms, and the impact of the Sun's behavior on radio transmissions will be provided in daily recorded messages from Goddard. The telephone number is 301/344-8129.

The daily recordings will originate in the Solar Maximum Mission's Experiment Operations Facility. They will include reports on the locations of active regions on the Sun, as well as on experiments being conducted aboard NASA's Solar Maximum Mission spacecraft during the next 24-hour period. Information provided by the recordings is expected to serve as a valuable resource to astronomers and other scientists, ground observers, amateur radio operators, and teachers interested in the Sun's activity.

NSTA Selected to Manage Shuttle Student Involvement Project

NASA has selected the National Science Teachers Association (NSTA) to manage the Shuttle Student Involvement Project (SSIP), a nationwide competition to be conducted annually among secondary students for scientific and engineering experiments to be performed on a "space available" basis aboard the Shuttle. The Space Shuttle is expected to be operational in 1982.

The project is part of a long-standing and continuing NASA program to involve the nation's secondary

school students in creative scientific activity. NASA Administrator Dr. Robert A. Frosch said, "The vitality of NASA depends heavily on an infusion of fresh ideas. Therefore, our connection with students is extremely valuable to us and is an important part of our program."

The SSIP competition will be conducted in the fall each year leading to the selection of winners the following spring. The contract with NSTA contains an option to conduct a second competition beginning in the fall of 1981. NSTA will formulate rules for the competition and define ten regions from which semifinalists will be selected. It will also distribute announcements, devise the entry/application forms and project rules, and manage the actual competition.

Twenty semifinalists will be chosen in each of the ten regions. Each region will hold a seminar at which semifinalists will discuss their proposals. The ten final winners will be named from this pool of approximately 200 regional choices. NASA retains final decision on whether it is possible to fly a particular experiment or accommodate winning students in some other fashion.

Student winners will also receive an expense-paid trip to NASA's Kennedy Space Center, Florida, to discuss their projects with other students, professional scientists, and NASA officials.

To broaden participation in the program, NASA plans to ask outside groups to sponsor the development and postflight analysis of the student experiments.

For information about the project, contact: Space Shuttle Program, National Science Teachers Association, 1742 Connecticut Avenue, NW., Washington, DC 20009.

Recent NASA Publications

Teacher's Guide for NF-58 Comparing the Planets, NF-109, is a 16-page pamphlet offering detailed information for using a NASA Facts wall chart about the solar system. $1.75 (Stock No. 033-000-00787-6).

The wall chart, *Comparing the Planets,* is also available. $1.50 (Stock No. 033-000-00744-2).

Project Orion, A Design Study of a System for Detecting Extrasolar Planets, SP-436, is a summary of the problem of detecting other planetary systems and the formulation of design concepts for conducting the search. Paperbound and illustrated, 204 pp., $5.50.

Lessons of the NASA Tech House, SP-442, is a 38-page booklet about the Technology Utilization house at NASA's Langley Research Center. A family lived for a year in the heavily-instrumented experimental house; this booklet discusses the results. $3.00 (Supt. of Docs. #NAS 1:21:442).

Images of Mars, SP-444, presents images from one of NASA's most extraordinary space missions. The photographs and texts provide an elegant look at the planet Mars as revealed by the Viking spacecraft since their arrivals and landings in 1976. 32 pp., $2.25.

NASA Aeronautics, EP-85, is a 27-page booklet describing NASA's research and development programs in aeronautics. Topics discussed include the tools of research, energy-efficient aircraft, quiet engines, revolutionary ideas, and general aviation. $2.00.

The above publications are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

Sheriff's Posse Brings Moon Rocks to Lucerne **is not only a picture caption, but also the title of a student's report. When the Lake County (CA) Integrated Science Project scheduled the Lunar Sample Educational Packet for local schools, the County's Mounted Sheriff's Posse delivered the treasure to the delight of Lucerne Elementary School children. The experience fascinated students in science classes and the event inspired them to write of their impressions.**

Where to Write for Services

NASA publications should be ordered from the Superintendent of Documents, Government Printing Office, Washington, DC 20402. Publication lists, film lists, and information about other services are available from the Educational Office at the NASA center serving your state. See the list below. There are special resource centers for educators at the Kennedy Space Center, Lewis Research Center, and Alabama Space and Rocket Center, Huntsville, AL.

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Moffet Field, California 94035
Alaska, Arizona, California, Hawaii, Idaho, Montana, Nevada, Oregon, Utah, Washington, Wyoming

NASA Goddard Space Flight Center
Greenbelt, Maryland 20771
Connecticut, Delaware, District of Columbia, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont

NASA Lyndon B. Johnson Space Center
Houston, Texas 77058
Colorado, Kansas, Nebraska, New Mexico, N. Dakota, Oklahoma, S. Dakota, Texas

NASA John F. Kennedy Space Center
Kennedy Space Center, Florida 32899
Florida, Georgia, Puerto Rico, Virgin Islands

NASA Langley Research Center
Hampton, Virginia 23665
Kentucky, N. Carolina, S. Carolina, Virginia, West Virginia

NASA Lewis Research Center
21000 Brookpark Road, Cleveland, Ohio 44135
Illinois, Indiana, Michigan, Minnesota, Ohio, Wisconsin

NASA George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812
Alabama, Arkansas, Iowa, Louisiana, Mississippi, Missouri, Tennessee

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Muriel M. Thorne, Editor

NASA Report to Educators
Vol. 8, No. 3 Fall 1980

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NASA Report To Educators

National Aeronautics and Space Administration

Vol. 8, No. 4 Winter 1980

Nov. 16, 1980

Saturn

Four days after Voyager 1 flew past Saturn it looked back to observe the appearance of the planet and its rings. In this picture taken from a distance of 5.3 million km (3.3 million mi), the Saturn crescent is seen through all but the densest portion of the rings, across which its shadow falls. A strikingly beautiful photograph, it is a fitting summary to a flawless mission.

Voyager's imaging of Saturn began in August 1980, ended in December. The machine was magnificent, it's performance perfection as it brought one of the most marvelous sights of the Solar System close to Earth's viewers. At the climax of its three-year journey, it was only 19 km (12 mi) off course. Its remarkable cameras sent back stunning, astonishingly clear pictures. Its experiments—only one was not working—produced another spectacular amount of data.

It returned more information about the planet than has been learned in the span of human history.

The Planet. The pale yellow image of Saturn seen through Earth-based telescopes has become a multi-hued world, a complex structure quite like yet distinct from the Jupiter that Voyager introduced to us last year.

The basic appearance of Saturn's atmosphere is similar to Jupiter's, with alternating dark and light cloud

NAS 1.49:

A view of Saturn's clouds in the northern hemisphere taken on Nov. 10, 1980, at a distance of 3,540,000 km (2,200,000 mi) shows a ribbon-like wave structure in the light belt and small convective cloud features in the dark belt.

markings, but the features in Saturn's atmosphere are muted by the presence of a much thicker haze layer above the visible clouds. The photographs also revealed a red cloud feature, an oval some 12,000 km (7456 mi) long (smaller than Jupiter's Great Red Spot), as well as other complex features—swirls, eddies, and curling ribbons—so familiar on Jupiter.

Despite the visual similarities, differences exist. Saturn's colors are not as varied as Jupiter's and the belts and zones, which extend to much higher latitudes, are more numerous. The wind speeds in Saturn's atmosphere are not closely tied to the belt/zone boundaries as they seemed to be for Jupiter. On Saturn the strongest winds are at the center of the belts and zones, just the opposite. The greatest wind speeds (more than 1600 km or 1000 mph) occur at the equator and are four to five times stronger than Jupiter wind speeds.

Temperatures near the cloudtops range from 86°K (-305°F) to 92°K (-294°F), with the coolest temperatures noted near the center of the equatorial zone.

Auroral emissions were seen near Saturn's poles, and auroral-type emissions in the ultraviolet were noted near the illuminated limbs of the planet.

The dark face of Saturn receives a substantial amount of light from the rings, especially in that hemisphere above the illuminated face of the rings.

Lightning bolts have not been observed in the images of Saturn's dark face, but radio emissions typical of lightning discharges have been noted. These discharges are believed to emanate from Saturn's rings rather than from its atmosphere.

In addition to these discoveries, radio emissions, primarily from the north polar region and near 90° longitude, indicate that the body of Saturn and its magnetosphere rotate with a period of 10 hours 39 minutes 26 seconds.

The Rings. Viewed from Earth, Saturn's most glorious feature is the dazzling sight of its rings. Majestic and mysterious, there is no more beautiful sight in the Solar System. Voyager has given them a new look, revealed their true nature. The once neatly defined rings, few in number, are a complex system, rings within rings, so numerous—upwards to 1000—that the count is not yet

complete. Voyager has revealed unexpected characteristics, and the magnificent rings turn out to be one of the Solar System's major puzzles.

The gaps are no longer empty. The Cassini Division consists of a series of rings about 500 km (300 mi) wide, separated by dark edges. The more detailed the pictures, the more the gap seems to be filled with material.

A, B, and C rings The multitude of tiny concentric rings in the three primary rings has likened the whole to the grooves of a phonograph record. A few of the newly-discovered rings are elliptical in shape.

The spokes discovered in the B ring are one of the most perplexing phenomenon. They extend radially thousands of miles through the concentric rings. They are dark in approach pictures and bright in forward-scattered light in post-encounter pictures, and may be the result of electrostatic forces lifting fine particles above the face of the optically thick B ring. The spokes appear to corotate with Saturn's magnetic field.

The material in the C ring and the Cassini Division appears distinctly different from that of the A and B rings with different reflective properties. Measurements of the C ring show an effective particle size of about 0.9 m (3 ft), but also suggest a wide distribution of particle sizes.

D and E rings The existence of a D ring inside of the C ring was confirmed by observations during Voyager's passage through the shadow of Saturn. The tenuous E ring, previously observed only from Earth during periods when Saturn's rings could be viewed edge-on, was also observed during shadow passage.

The existence of a thin ring just inside the coorbital moons S-10 and S-11 was first inferred from the passage of its shadow across one of the moons, and thereafter directly detected in the Voyager image of the E ring.

Measurements show that the D, E, and F rings have a large population of particles less than 1/10,000 of an inch in diameter.

The dark spokelike features in the B ring are seen revolving around the planet in these six photographs taken on October 25, 1980, in sequence from upper left to lower right. (Dark round spots on the rings and planet are reseau marks engraved on the camera.)

F ring The F ring, first discovered by Pioneer 11, contains three separate rings which appear to be intertwined for long stretches of the ring, another baffling phenomenon. Equally uncharactistic are several clumps found in the F ring, moving at the orbital speed of the ring.

The inner and outer limits of the F ring seem to be controlled by two shepherding satellites, S-13 on the outside and S-14 on the inside. The outer edge of ring A is similarly shepherded by S-15. All three of these satellites were discovered by Voyager 1.

The intertwined rings of the F ring photographed at a distance of 756,300 km (470,000 mi). A diffuse component about 32 km (20 mi) in width is also visible, as are the clumps of ring material.

The Satellites. Voyager explored several of Saturn's moons, which until now, had been but small points of light when seen in Earth telescopes.

Titan On its way to Saturn the spacecraft flew within 4023 km (2500 mi) of its largest moon. Once thought to be the largest satellite in the Solar System, Titan is now known to be smaller than Ganymede, largest of Jupiter's Galilean satellites. Its precise diameter is not yet known, but it is less than 5120 km (3180 mi) compared with Ganymede's 5270 km (3275 mi). This implies a density twice that of water ice for Titan, requiring it to be an equal amount of rock and ice, as is Ganymede.

Titan's surface cannot be seen because it is hidden by a dense haze at least 280 km (175 mi) thick, but radio signals suggest the atmosphere pressure near its surface is 50 percent greater than that of Earth. Above the main haze layer are three distinct detached haze layers that merge into a darkened hood over the north pole. Titan's southern hemisphere is somewhat brighter than its northern, perhaps as a result of seasonal effects.

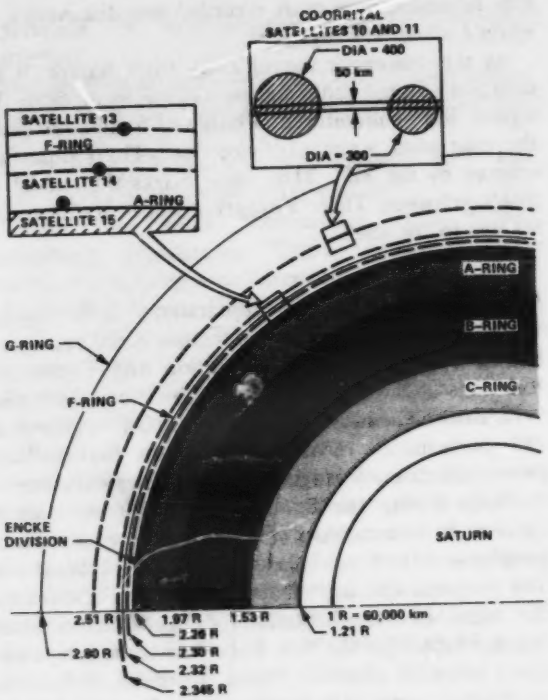
The atmosphere contains methane, ethane, acetylene, ethylene, and hydrogen cyanide, but the bulk of the atmosphere is now believed to be composed of nitrogen, the main constituent of Earth's atmosphere. Lakes of liquid nitrogen may exist near the poles, whose surface temperature is probably 90°K (-300°F), only slightly warmer than the boiling point of liquid nitrogen.

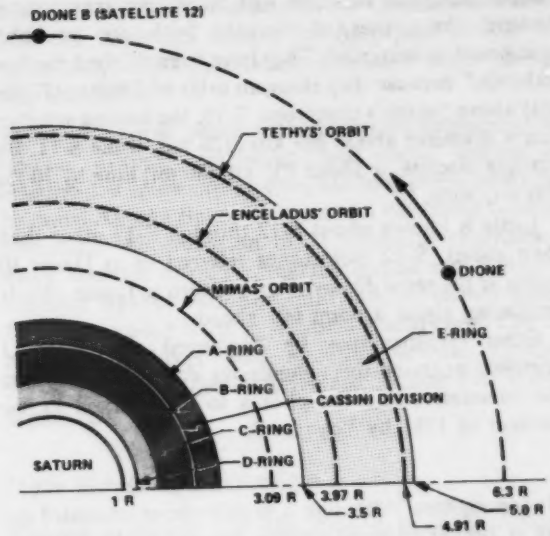
Titan has no intrinsic magnetic field, and therefore possesses no large liquid conducting core. It does, however, serve as a small source of charged particles in Saturn's atmosphere.

Inner satellites Mimas, Enceladus, Tethys, Dione, and Rhea, the five inner moons of Saturn are approximately spherical in shape. Their densities and surface brightnesses indicate that they are composed mainly of water ice. Tethys seems to be almost pure ice, whereas Dione may range from 30 to 70 percent rock.

All five represent a size of body not previously explored by space probes, intermediate in size between Phobos and Deimos (Mars' moons) and Amalthea (Jupiter's), and terrestrial-sized bodies (Mercury, Moon, and the Galilean satellites of Jupiter). Their diameters, accurate to about 20 km (12 mi), are: Mimas, 390 km (240 mi); Enceladus, 500 km (310 mi); Tethys, 1050 km (650 mi); Dione, 1120 km (695 mi); and Rhea, 1530 km (950 mi).

Voyager picture showing a large impact structure on Mimas, which may have the largest crater diameter/satellite diameter ratio in the Solar System.





With the exception of Enceladus, all have heavily cratered surfaces. Mimas has a prominent crater with a diameter almost one-fourth that of Mimas itself. Tethys has a 60-km (40-mi) wide valley stretching for 750 km (470 mi) across its surface, which appears to be a fracture in the crust of the moon. Dione has several sinuous valleys, some of which appear to branch. Both Dione and Rhea have brighter wispy streaks which stand out against an already high reflective surface. These are probably the result of relatively fresh ice ejecta thrown out of more recent (on a geologic time scale) impact craters.

Of these five inner moons, Enceladus seems to be the smoothest; it shows no evidence of impact craters. Because the maximum intensity of the E ring occurs near the orbit of Enceladus, the satellite may serve as a source for E ring particles. Enceladus was not a prime target for Voyager 1, but next year Voyager 2 will fly closer and return higher resolution images.

Outer satellites Of the three known outer satellites, Voyager 1 studied from a distance only Hyperion and Iapetus. Tiny Phoebe will be studied by Voyager 2. Little is known of the masses of Hyperion and Iapetus so their densities are uncertain, but it is likely that they too are mainly water ice. Their surfaces are somewhat less reflective than the inner moons, but much more so than our own Moon, which reflects only four percent of the light it receives from the Sun. Hyperion has a diameter of about 310 km (190 mi), Iapetus a diameter of about 1440 km (890 mi).

Saturn's satellite Iapetus from a distance of 3.2 million km (1.9 million mi). The satellite's leading hemisphere is to the left, and the trailing, brighter hemisphere to the right.

Iapetus is peculiar in that it has one bright and one dark hemisphere. The dark side, which faces forward as it circles Saturn, reflects only one-fifth as much as the bright trailing side.

New satellites S-10, S-11, S-12, S-13, S-14, and S-15, recently discovered moons of Saturn, were all photographed, but only S-10 and S-11 had large enough angular diameters in the images to determine their shapes. Irregular in shape with their long axes pointed toward the center of Saturn, both are probably composed of water ice. They have been dubbed the "co-orbitals," because they share an orbit 91,000 km (57,000 mi) above Saturn's cloudtops. S-10, the leading satellite, has a diameter about 200 km (120 mi), while S-11, the trailing satellite, is about 135 km (80 mi) long by 70 km (40 mi) wide.

Little is known about S-12 through S-15 other than their orbits. S-12 (sometimes referred to as Dione B) orbits at the same distance from Saturn as Dione, slowly oscillating about a point 60° ahead.

Other satellites may be discovered as Voyager 1 scientists examine the voluminous data returned from the encounter, or from photos to be returned in the summer of 1981 by Voyager 2.

Magnetosphere. Although it is only about one-third the size of Jupiter's magnetosphere, Saturn's magnetosphere is still an enormous structure, extending nearly 1,609,300 km (a million mi) from the planet toward the Sun before the flow of charged particles in the solar wind overcomes the effects of Saturn's magnetic field. The size of the magnetosphere fluctuates rhythmically as the solar wind increases or decreases in intensity. Thus sometimes the magnetosphere is inside Titan's orbit, and at times Titan finds itself outside of the magnetosphere altogether.

Charged particles in the planet's magnetosphere are dragged along by the magnetic field and circle Saturn once every 10 hours 39 minutes. These charged particles speed by Titan at more than 193 km (120 mi) per second.

Close to the planet, Saturn's rings act as an effective shield or absorber of charged particles. The rings themselves are apparently substantially affected in this process, however, as evidenced by the spokes of fine particles and the lightning-like electrical discharges attributed to the rings.

To its discoveries, Voyager added a vast cloud of uncharged hydrogen atoms that surrounds Titan and its orbit and extends inward to the orbit of Rhea to form a torus, or ring, of ultraviolet-emitting particles. Because they are uncharged, these atoms are not dragged along by Saturn's magnetic field as it rotates, but rather orbit as countless miniscule moons around Saturn.

Voyager 1. Voyager's primary mission is completed. Its encounter with Saturn was a thrilling event for both scientists and laity. Its instruments once again introduced a new look for an old planet, again expanded our vision beyond anything the discoverers of the planets ever dreamed, once more recorded new discoveries, yet again evoked new mysteries.

As the spacecraft moves away from Saturn, it will continue to send radio signals as long as possible. The signals will be monitored in hopes of finding the end of the solar wind, a stream of electrically-charged particles emitted by the Sun. That point marks the end of the Sun's influence. There Voyager 1 will begin its endless voyage to the stars.

Educators Conference. In conjunction with the Voyager 1 Saturn Encounter, an Educators Conference was hosted by the Office of Education and Community Relations at the Jet Propulsion Laboratory, November 9-12. **Benito Casados,** Manager of the Office, guided the 485 participants through a program that included presentations on Voyager and its science experiments, briefings during the Saturn and satellite encounters, spacecraft communications, and future astronomy programs as well as visits to several JPL laboratories. The program also included a symposium, "Saturn and the Mind of Man." Moderated by Walter Sullivan, Science Editor for the New York Times, the symposium panel included physicist Philip Morrison, astronomer Carl Sagan, writer Ray Bradbury, and Bruce C. Murray, Director of the Jet Propulsion Laboratory.

1980 International Science and Engineering Fair

At the 31st International Science and Engineering Fair held in St. Paul, Minnesota, May 5-10, eight students received NASA awards in recognition of creative scientific endeavor in aerospace research. A team of judges from the NASA Langley and Lewis Research Centers and University of Minnesota faculty selected the students who received a Certificate of Merit signed by Dr. Robert A. Frosch, NASA Administrator, and Mr. E. G. Sherburne, Jr., Director of Science Service, sponsor of the ISEF. The students also received an expense-paid trip with their teachers to the Jet Propulsion Laboratory, California, for the November 12 Voyager 1 Encounter with Saturn.

The award-winning students, their schools, and their research were as follows:

Kenneth G. Baird, Cocoa High School, Cocoa, Florida, "The Design and Analysis of an Ion Propulsion Thruster"

William Francis Doyle, Centennial High School, Ellicott City, Maryland, "Quantitative Analysis of Photographic Characteristics Using Video Techniques"

Paul Douglas Froula, Cleveland High School, Cleveland, Tennessee, "Plane Hexagonal Geometry: An

Experiment in Dimensional and Morphological Restriction"

Monroe B. Harden, Thomas B. Doherty High School, Colorado Springs, Colorado, "The Aerodynamic Drag of Model Rockets"

Alan Hedge, Leland High School, San Jose, California, "Digital Image Compression"

Daniel H. Linder, Hattiesburg High School, Hattiesburg, Mississippi, "Digital Computer Using Medium-Scale Integrated Circuitry"

David H. Peace, Portville Central High School, Portville, New York, "Experiments with a Spital Fin Absorber Tube in an Evacuation Solar Collector"

Tammy I. Winsted, Springdale High School, Springdale, Arkansas, "Mechanisms of Flight in *Odonta* and *Diptera*"

In addition, 11 students were awarded Honorable Mention, with each student receiving a mounted photo mosaic of images taken by NASA spacecraft of six of the planets in the Solar System and Earth's Moon: **Frank Lynn Brevard,** Ballou High School, Washington, DC; **Marie Christian,** Dixie High School, St. George, UT; **Elliott Fishman,** Three Tuns Junior High School, Maple Glen, PA; **Michelle Marie Ginella,** Ursuline High School, Santa Rosa, CA; **Bruce Kleinman,** Boca Raton Community High School, Boca Raton, FL; **Mark W. Miles,** Frederick Douglass High School, Atlanta, GA; **Tracy Peters,** Kelly Walsh High School, Casper, WY; **Chris Poor,** Service High School, Anchorage, AK; **Ron Taylor,** Roy High School, Roy, UT; **Kenneth Richard Traub,** John Adams High School, South Bend, IN; **Stephen Van Sickle,** West Jefferson High School, Harvey, LA.

1981 National Congress on Aerospace Education

Educators will gather in San Antonio, Texas, April 2-4, for the 1981 National Congress on Aerospace Education. Designed for everyone interested in aerospace education, the Congress will feature grade level dialogue sessions, nationally known speakers, field trips, and presentation of the Crown Circle Awards for Aerospace Education.

Headquarters for this 14th annual congress will be the El Tropicano Hotel. Rates: $28, single; $38, double. The basic Congress Registration fee, if mailed before March 1, is $40; after that date, $45. Send your name and address and school/organization/firm address to National Congress on Aerospace Education, HQ CAP/EDF, Maxwell AFB, AL 36112.

New Aerospace Materials

Directory of Aviation/Space Education. Copies of the updated 3rd edition of the directory, which lists hundreds of aerospace education resources, are available from the American Society for Aerospace Education, Suite 1303, 1750 Pennsylvania Avenue, NW., Washington, DC 20006.

Flight, a unique series of soundstrips exploring the science, history, technology, and social impact of aviation and space exploration, has been prepared by the National Air and Space Museum. An illustrated booklet describing the collection of 21 dramatic programs—which trace the world's eternal fascination with flight—is available free for both elementary and secondary levels. To obtain a copy write to National AudioVisual Center, National Archives and Records Service, General Services Administration/Reference Section EH, Washington, DC 20409.

New NASA Publication

Voyager to Jupiter, SP-439, is the story of the Voyager mission and its people, and the spacecraft's findings as they flew by Jupiter in the spring and summer of 1979. The text relates the excitement of the flyby and presents the science of the mission in a manner easily understood; the photographs provide a spectacular view of the Jovian system. Paperbound, 211 pp., $7.50. Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

High Energy Astronomy Observatory, EP-167, is a 36-page booklet describing the HEAO program. Focussing on the HEAO-2 (Einstein) Observatory's scientific results, there are also brief discussions of high energy astrophysics, HEAO 1, and HEAO 3, as well as a glossary. The text is illustrated with the breath-taking color photographs taken by HEAO 2's X-ray telescope. $2.50. Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

Correction

Typing, proofreading, and unfathomable flaws in editing sent some measurements awry in the Fall issue. On page 1 under Typography, 1000 m should be followed by (3300 ft), and under Maxwell Montes, page 3, the "rocks larger than 10 cm" should be followed by "(4 in)."

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NASA Goddard Space Flight Center
Greenbelt, Maryland 20771
Connecticut, Delaware, District of Columbia, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont

NASA Lyndon B. Johnson Space Center
Houston, Texas 77058
Colorado, Kansas, Nebraska, New Mexico, N. Dakota, Oklahoma, S. Dakota, Texas

NASA John F. Kennedy Space Center
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Florida, Georgia, Puerto Rico, Virgin Islands

NASA Langley Research Center
Hampton, Virginia 23665
Kentucky, N. Carolina, S. Carolina, Virginia, West Virginia

NASA Lewis Research Center
21000 Brookpark Road, Cleveland, Ohio 44135
Illinois, Indiana, Michigan, Minnesota, Ohio, Wisconsin

NASA George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812
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